# MEASURING DEVICE

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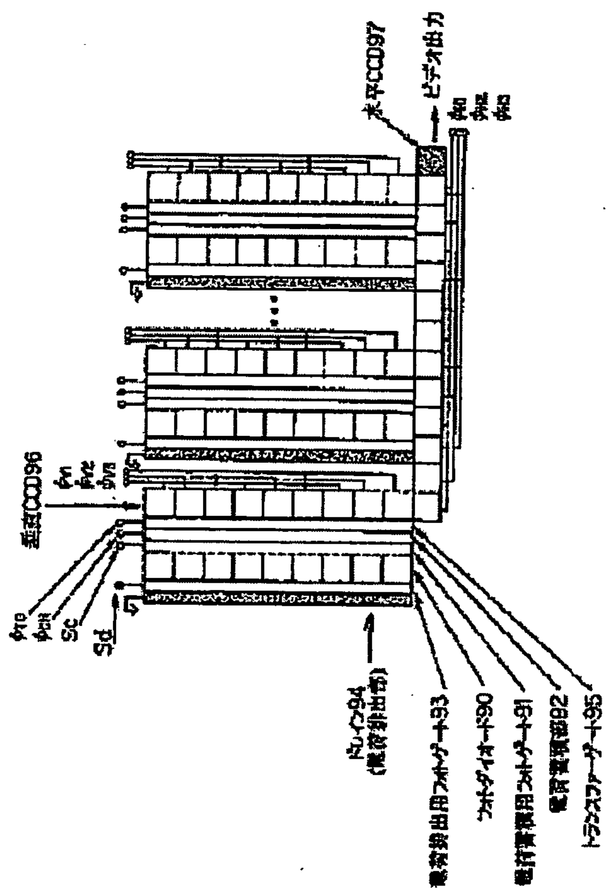
Abstract of **JP2001268445**

PROBLEM TO BE SOLVED: To provide a small-sized and inexpensive photosensor and a three- dimensional shape measuring device capable of highly accurately measuring a distance to an object in a short time. SOLUTION: This photosensor is provided with two-dimensionally arrayed plural signal generation means 96 which is equipped with a photoelectric conversion part 90 for converting incident light to a signal current, a sampling part 91 for sampling the signal current in a prescribed cycle, a storage part 92 for storing signal charges corresponding to the sampled signal current and a discharge part 93 for discharging unwarted charges stored in the photoelectric conversion part and a parasitic capacitance formed at the periphery in the period in which the sampling part does not perform sampling, and also provided with a read means 97 for reading the signal charges stored in the storage part of the plural signal generation means.



## CLAIMS

[Claim(s)]

[Claim 1] The photo-electric-conversion section which carries out photo electric conversion of the incident light to the signal current, and the sampling section which samples said signal current with a predetermined period, The are recording section which accumulates the signal charge corresponding to said signal current sampled by said sampling section, Two or more signal generation means which have the discharge section which discharges the unnecessary charge accumulated in the parasitic capacitance formed around said photo-electric-conversion section and said photo-electric-conversion section at the period which said sampling section has not sampled, and were arranged in the shape of two-dimensional, It is the photosensor which is equipped with the read-out means which reads said signal charge accumulated in said are recording section of two or more of said signal generation means, and is characterized by constituting said sampling section and said discharge section using the photograph gate.

[Claim 2] It is the photosensor according to claim 1 which said photo-electric-conversion section carries out photo electric conversion of the on-the-strength strange modulated light by which intensity modulation was carried out on the predetermined frequency as said incident light, said sampling section samples said signal current about two or more phases of said on-the-strength strange modulated light, and said are recording section accumulates said signal charge for said every phase, and is characterized by said read-out means being a configuration which reads said signal charge for said every phase.

[Claim 3] Said photo-electric-conversion section carries out photo electric conversion of the on-the-strength strange modulated light by which intensity modulation was carried out on the predetermined frequency as said incident light. Said sampling section The multiple-times sampling of said signal current is carried out, respectively about two or more phases of said on-the-strength strange modulated light. Said are recording section It is the photosensor according to claim 1 which accumulates said signal charge for said multiple times for said every phase, and is characterized by said read-out means being a configuration which reads the signal charge for said multiple times for said every phase.

[Claim 4] Said sampling section is a photosensor according to claim 2 or 3 characterized by being constituted so that the phase corresponding to the maximum

amplitude of said on-the-strength strange modulated light may be contained in said two or more phases.

[Claim 5] It connects with the output side of said photo-electric-conversion section, and said sampling section is equipped with the photograph gate for charge storages driven by the are recording pulse of a predetermined period. Said are recording section Said photograph gate for charge storages is adjoined, and said signal charge corresponding to said signal current which flows through said photograph gate for charge storages from said photo-electric-conversion section is accumulated. Said discharge section The photosensor according to claim 1 characterized by being the configuration equipped with the photograph gate for charge discharge which connects with a drain and is driven by said are recording pulse and discharge pulse of opposition.

[Claim 6] The light emission gunner stage which turns and carries out outgoing radiation of the on-the-strength strange modulated light by which intensity modulation was carried out to a body on a predetermined frequency, In the three-dimensions shape-measurement equipment which has the photosensor which receives a synthetic light of the reflected light from said body, and said on-the-strength strange modulated light, and outputs a detecting signal, and an operation means to calculate the distance to said body based on said detecting signal The photo-electric-conversion section to which said photosensor carries out photo electric conversion of said on-the-strength strange modulated light to the signal current, The sampling section which samples said signal current with a predetermined period, and the are recording section which accumulates the signal charge corresponding to said signal current sampled by said sampling section, Two or more signal generation means which have the discharge section which discharges the unnecessary charge accumulated in the parasitic capacitance formed around said photo-electric-conversion section and said photo-electric-conversion section at the period which said sampling section has not sampled, and were arranged in the shape of two-dimensional, It is three-dimensions shape-measurement equipment which is equipped with the read-out means which reads said signal charge accumulated in said are recording section of two or more of said signal generation means, and is characterized by constituting said sampling section and said discharge section using the photograph gate.

[Claim 7] Said sampling section samples said signal current about two or more phases of said on-the-strength strange modulated light. Said are recording section Said signal charge is accumulated for said every phase. Said read-out means It is three-dimensions shape-measurement equipment according to claim 6 which reads

said signal charge for said every phase, and is characterized by said operation means being the configuration of calculating the maximum amplitude of said on-the-strength strange modulated light based on said signal charge which shows maximum among said signal charges of two or more of said phases.

[Claim 8] Said sampling section carries out the multiple-times sampling of said signal current, respectively about two or more phases of said on-the-strength strange modulated light. Said are recording section Said signal charge for said multiple times is accumulated for said every phase. Said read-out means It is three-dimensions shape-measurement equipment according to claim 6 which reads the signal charge for said multiple times for said every phase, and is characterized by said operation means being the configuration of calculating the maximum amplitude of said on-the-strength strange modulated light based on said signal charge which shows maximum among said signal charges of two or more of said phases.

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] About the photosensor and three-dimensions shape-measurement equipment which measure the distance to an object object, especially, this invention is small and cheap and relates the distance to an object object to a short time, the photosensor which can be measured with high precision, and three-dimensions shape-measurement equipment.

[0002]

[Description of the Prior Art] Two, a passive method and an active method, are proposed as a method which measures a three-dimensions configuration. A passive method is a method which measures a configuration, without emitting energy to an object object, and an active method is a method which measures a configuration by emitting a certain energy to an object object, and detecting the reflection.

[0003] In a passive method, there is the stereo method as one of the approaches of measuring the distance of two or more points to an object object. This stereo method is a method which measures the distance to an object object by trigonometry from the parallax of two images set, installed and obtained [ spacing / a certain ] in two cameras. Although there are the features that the distance to a distant place is measurable if this method can be incorporated as an image, the serious trouble that three-dimensions measurement of the whole front face with a smooth field without a

pattern cannot be performed exists. Moreover, since it was not able to perform theoretically making the optical axis of two cameras in agreement, there was a fault that the field (occlusion) which cannot measure distance occurred.

[0004] In the active method, there is an optical cutting method as one of the approaches of measuring the distance of two or more points to an object object. This optical cutting method is a method which measures the distance to an object object by trigonometry from the image which irradiated the object object at a certain include angle, and picturized slit light from the include angle different from it. Although there are the features that this method is realizable with a comparatively easy configuration, in order to have to scan slit light in a very small include-angle unit and to picturize an image to whenever [ that ], there is a trouble that measurement time amount becomes long. In order to solve this trouble, the space coding method is in the method adapting an optical cutting method. Although this space coding method was a method which measures distance by the small count of projection by coding the pattern of projection light instead of irradiating slit light repeatedly, it had the trouble that the measuring time became long in order to have to perform the image pick-up of a log2n time (9 times as n= 512 points), if a horizontal measurement size is set to n. Moreover, since it was not able to perform theoretically making in agreement the optical axis of a projector and an image pick-up machine, there was a fault that the field (occlusion) which cannot measure distance occurred.

[0005] In the active method, the light by which intensity modulation was carried out is irradiated at an object object as one of the methods which can measure the distance of two or more points by one image pick-up, and there is a phase distribution measurement method which measures phase distribution of the reflected light.

[0006] As a conventional phase distribution measurement method, for example "Reference 1 2588 or SPIE Vol. 1995, and 126 - 134 the paper (An new active3D-Vision system based on rf-modulation interferometry light) indicated by the page" -- And there will be some which are shown in 47-59 pages "The Emerging Versatility of aScannless Range Imager" in patent No. 2690673 and SPIEVol. 1996 [ 2748 or ].

[0007] Drawing 8 shows the conventional three-dimensions shape-measurement equipment shown in reference 1. Modulation/recovery signal generator 104 which performs intensity modulation to the light by which outgoing radiation of this three-dimensions shape-measurement equipment 100 was carried out to the flat-surface modulator 103 using a crystal like pocket RUZUSERU through the condenser lens 102 from light source 101A, The projection lens 106 which carries out

the flat-surface exposure of the optical 105a by which intensity modulation was carried out at the object object 6, It has modulation/recovery signal generator 104 which gives a recovery on the strength to reflected light 105b which reflected with the object object 6 and carried out incidence to the flat-surface demodulator 108 using a crystal like pocket RUZUSERU through the image formation lens 107, and CCD camera 109 which picturizes the lightwave signal to which the recovery on the strength was given. In such a configuration, after carrying out incidence of the light emitted from light source 101A to the flat-surface modulator 103 with a condenser lens 102 and performing intensity modulation based on the signal of modulation/recovery signal generator 104, the flat-surface exposure of the optical 105a by which intensity modulation was carried out is carried out with the projection lens 106 at the object object 6. After carrying out incidence of the reflected light 105b from the object object 6 to the flat-surface demodulator 108 with the image formation lens 107 and giving a recovery on the strength to it based on the signal of modulation/recovery signal generator 104, image formation of it is carried out on CCD camera 109. The shade image picturized with CCD camera 109 includes the topology resulting from the distance to the object object 6. By processing this shade image by computer 110, the distance data of the object object 6 can be obtained by one image pick-up.

[0008] Drawing 9 shows the conventional three-dimensions shape-measurement equipment indicated by the patent No. 2690673 official report. The demodulator using a crystal like that semiconductor laser 101B is used for the difference with drawing 8 as the light source, performing direct intensity modulation by semiconductor laser 101B, without using the modulator using a crystal like pocket RUZUSERU, and pocket RUZUSERU is three points of getting over with the image intensifier 111, without using. After the light to which intensity modulation was performed based on the signal of modulation/recovery signal generator 104 is emitted from semiconductor laser 101B, the flat-surface exposure of it is carried out with the projection lens 106 at the object object 6. Image formation of the reflected light 105b from the object object 6 is carried out to an image intensifier 111 with the image formation lens 107. The reflected light by which the on-the-strength recovery was carried out is picturized with CCD camera 109 by changing the signal of modulation/recovery signal generator 104 into a high-pressure signal by the high-pressure drive circuit 112, and inputting it into the gain controller terminal of an image intensifier 111. The shade image picturized with CCD camera 109 includes the topology resulting from the distance to the object object 6. By processing this shade image by computer 110, the distance

data of the object object 6 can be obtained by one image pick-up.
[0009]
[Problem(s) to be Solved by the Invention] However, since the modulator/demodulator which used a crystal like pocket RUZUSERU for the flat-surface modulator 103 and the flat-surface demodulator 108 were used according to the conventional three-dimensions shape-measurement equipment shown in drawing 8 , there was a fault of becoming very expensive equipment. Moreover, since the modulator/demodulator using this crystal had opening as small as divisor millimeter extent, it had to condense the light reflected with the light and the object object 6 which were emitted from light source 101A using condenser lenses 102 and 107 according to this opening, and had the fault that equipment will be enlarged.
[0010] Moreover, according to the conventional three-dimensions shape-measurement equipment shown in drawing 9 , since the image intensifier 111 was used, there was a fault of becoming very expensive equipment. Moreover, since it was required to carry out intensity modulation of the high-voltage signal of hundreds of volts in order to drive this image intensifier 111, there was a fault that a drive circuit became complicated. Moreover, this image intensifier 111 had the fault that the whole equipment will be enlarged since it is large compared with CCD camera 109.
[0011] On the other hand, although using the two-dimensional MOS image sensors which are typical two-dimensional sensors, and two-dimensional CCD series is also considered in order to attain a miniaturization in the sensor which can detect light, since these image sensors have only the function to integrate with a signal charge by the storage time, there is no recovery function required for distance measurement, and it cannot use these as a photosensor of three-dimension shape-measurement equipment.
[0012] Therefore, the purpose of this invention is small and cheap, and is about the distance to an object object to offer a short time, the photosensor which can be measured with high precision, and three-dimensions shape-measurement equipment.
[0013]
[Means for Solving the Problem] The photo-electric-conversion section which carries out photo electric conversion of the incident light to the signal current in order that this invention may realize the above-mentioned purpose, The sampling section which samples said signal current with a predetermined period, and the are recording section which accumulates the signal charge corresponding to said signal current sampled by said sampling section, Two or more signal generation means which have the discharge section which discharges the unnecessary charge accumulated in the parasitic

capacitance formed around said photo-electric-conversion section and said photo-electric-conversion section at the period which said sampling section has not sampled, and were arranged in the shape of two-dimensional, Having the read-out means which reads said signal charge accumulated in said are recording section of two or more of said signal generation means, said sampling section and said discharge section offer the photosensor characterized by being constituted using the photograph gate. According to the above-mentioned configuration, by discharging the unnecessary charge accumulated in the parasitic capacitance formed around the photo-electric-conversion section and the photo-electric-conversion section at the period which the sampling section has not sampled, only the signal charge generated at the period of the sampling by the sampling section is accumulated in the are recording section, and an exact signal charge is obtained.

[0014] The light emission gunner stage which turns to a body the on-the-strength strange modulated light by which intensity modulation was carried out, and carries out outgoing radiation on a predetermined frequency in order that this invention may realize the above-mentioned purpose, In the three-dimensions shape-measurement equipment which has the photosensor which receives a synthetic light of the reflected light from said body, and said on-the-strength strange modulated light, and outputs a detecting signal, and an operation means to calculate the distance to said body based on said detecting signal The photo-electric-conversion section to which said photosensor carries out photo electric conversion of said on-the-strength strange modulated light to the signal current, The sampling section which samples said signal current with a predetermined period, and the are recording section which accumulates the signal charge corresponding to said signal current sampled by said sampling section, Two or more signal generation means which have the discharge section which discharges the unnecessary charge accumulated in the parasitic capacitance formed around said photo-electric-conversion section and said photo-electric-conversion section at the period which said sampling section has not sampled, and were arranged in the shape of two-dimensional, Having the read-out means which reads said signal charge accumulated in said are recording section of two or more of said signal generation means, said sampling section and said discharge section offer the three-dimensions shape-measurement equipment characterized by being constituted using the photograph gate.

[0015]

[Embodiment of the Invention] Drawing 1 shows the three-dimensions shape-measurement equipment concerning the gestalt of operation of the 1st of this

invention. The modulating-signal generator 2 by which this equipment 1 generates a modulating signal, and the semiconductor laser 3 which carries out outgoing radiation of the illumination-light 4a which consists of a laser beam based on the modulating signal from the modulating-signal generator 2, The projection lens 5 which turns illumination-light 4a from semiconductor laser 3 to the object object 6, and irradiates it, The image formation lens 7 which carries out image formation of the body light 4b reflected with the object object 6 on a photosensor 9 through a light filter 8, The half mirror 10 which is made to penetrate a part of illumination-light 4a from semiconductor laser 3, is made to reflect the remainder as reference beam 4c, and is led on a photosensor 9 through a light filter 8, 1st liquid crystal shutter 11A arranged between the object object 6 and a light filter 8, 2nd liquid crystal shutter 11B arranged between a half mirror 10 and a light filter 8, The pulse generating section 12 which outputs a pulse signal to a photosensor 9, and the comparator circuit 13 which compares the size of the output signal of a photosensor 9, While having CPU, ROM, RAM, etc. and controlling each part of this equipment 1 with the distance operation part 14 which computes the distance data about the shape of surface type of the object object 6 two-dimensional based on the comparison result of a comparator circuit 13, it has the computer 15 which displays the result of an operation of the distance operation part 14.

[0016] Semiconductor laser 3 carries out outgoing radiation of the illumination-light 4a which consists of fixed light by which intensity modulation is not carried out based on the normal signal from the modulating-signal generator 2 while carrying out outgoing radiation of the illumination-light 4a which consists of a laser beam by which intensity modulation was carried out based on the modulating signal from the modulating-signal generator 2. This fixed light has the optical reinforcement which was in agreement with the average reinforcement of illumination-light 4a by which intensity modulation was carried out.

[0017] The 1st and 2nd liquid crystal shutters 11A and 11B can control permeability now in 0 - 100% of range by controlling applied voltage for every pixel. in addition, the shutters 11A and 11B -- every pixel -- you may not be -- all pixels -- the same permeability is sufficient. Moreover, package cutoff may be carried out, using a mechanical shutter as a shutter.

[0018] While the pulse generating section 12 generates the discharge pulse signal Sd which drives are recording pulse signal Sc which drives the photograph gate for charge storages, and the photograph gate for charge discharge Transfer gate pulse phiTG which is the pulse which carries out a seal of approval to the transfer gate and

the analog register (CCD) which function in order [ which reads outside the signal charge accumulated in charge storage section seal-of-approval pulse phiCH which is the pulse which carries out a seal of approval to the charge storage section, and the charge storage section ] to read, The perpendicular CCD seal-of-approval pulse phiV1, phiV2, phiV3 and the level CCD seal-of-approval pulse phiH1, phiH2, and phiH3 are generated.

[0019] Drawing 2 shows the modulating-signal generator 2. The modulating-signal generator 2 is equipped with the current signal mixer 22 which compounds the modulation current source 20 which outputs a modulating signal, the source 21 of a direct current which outputs a normal signal, the output signal of the modulation current source 20, and the output signal of the source 21 of a direct current, and is outputted to semiconductor laser 3.

[0020] Drawing 3 shows a photosensor 9. This photosensor 9 is considering the two-dimensional CCD (Charge Coupled Device) sensor as the basic configuration. Two or more photodiodes 90 arranged in the shape of [ which carries out photo electric conversion of the incident light to the signal current according to the optical reinforcement ] two-dimensional, The photograph gate 91 for charge storages which samples the signal current by which was established every photodiode 90 and photo electric conversion was carried out with the photodiode 90 according to are recording pulse signal Sc of the predetermined period of the pulse generating section 12, The charge storage section 92 which accumulates the signal charge corresponding to the sampled signal current, and also has a charge transfer facility by transfer pulse signal phiCH from the pulse generating section 12 further, The photograph gate 93 for charge discharge which is generated from the pulse generating section 12 and discharges the unnecessary charge accumulated in the parasitic capacitance formed around the photodiode 90 and the photodiode 90 according to the discharge pulse signal Sd of are recording pulse signal Sc and opposition, The drain 94 which discharges to a gland the unnecessary charge discharged from the photograph gate 93 for charge discharge, The transfer gate 95 for transmitting the signal charge accumulated in the charge storage section 92 to perpendicular CCD96 by transfer pulse signal phiTG from the pulse generating section 12, Perpendicular CCD96 which receives the signal charge transmitted through the transfer gate 95, and is further transmitted to level CCD97 by three steps of transfer pulse signals phiV1 from the pulse generating section 12, phiV2, and phiV3, It is prepared every perpendicular CCD96 and has level CCD97 for outputting outside as a video outlet by three steps of transfer pulse signals phiH1 from the pulse generating section 12, phiH2, and phiH3.

[0021] Next, actuation of the three-dimensions shape-measurement equipment 1 applied to the gestalt of the 1st operation with reference to drawing 3 - drawing 7 is explained.

[0022] Drawing 10 shows a charge transfer typically from charge generating of the existing CCD series, and explains the mechanism by which a charge is transmitted to the gate in the metal-oxide-semiconductor structure seen by CCD based on this drawing by carrying out the seal of approval of the electrical potential difference. The photograph gate 910 turns into the gate which determines the height of the potential which performs a charge storage. The photograph carrier 980 by which photo electric conversion was carried out with the photodiode 900 is accumulated in the potential well under the photograph gate 910. If the height of the potential under the transfer gate 950 is set to Low from High, the stored charge under the photograph gate will be transmitted to the CCD register 960.

[0023] Drawing 4 shows a charge transfer typically from charge generating of the photosensor which considered the CCD series of this invention as the basic configuration. The charge transfer mechanism of CCD is used and the RF sampling of the charge generated from a photodiode 90 is carried out. The photograph gate 91 for charge storages is formed next to a photodiode 90, and the charge storage section 92 is formed between this photograph gate 91 for charge storages, and the transfer gate 95. The photograph gate 93 for charge discharge contiguous to a photodiode 90 is established in somewhere else [ the photograph gate 91 for charge storages ], and a drain 94 is further formed in the point of the photograph gate 93 for charge discharge. The CCD analog register 960 is formed in the point of the transfer gate 95 connected to the charge storage section 92.

[0024] - Charge storage mode ( drawing 4 (a))

The height of each potential of the photograph gate 91 for photograph gate 93(Sd) for charge discharge charge storages (Sc), the charge storage section 92 (phiCH), and the transfer gate 95 (phiTG) is set as High, Middle, Low, and High. These are controlled by the pulse signals Sd and Sc from the previous pulse generating section 12, phiCH, and phiTG. The height of a seal-of-approval pulse voltage and potential becomes reverse relation here. That is, when a seal-of-approval electrical potential difference is High, the height of potential serves as Low. The photograph carrier 98 by which photo electric conversion was carried out with the photodiode 90 is accumulated in the potential well under the charge storage section 92. The photograph carrier 98 is equivalent to a signal charge.

[0025] - Charge discharge mode ( drawing 4 (b))

The height of each potential of the photograph gate 91 for photograph gate 93(Sd) for charge discharge charge storages (Sc), the charge storage section 92 (phiCH), and the transfer gate 95 (phiTG) is set as Low, High, Low, and High. These are controlled by the pulse signals Sd and Sc from the previous pulse generating section 12, phiCH, and phiTG. The photograph carrier 98 by which photo electric conversion was carried out is discharged by the drain 94 via the photograph gate 93 for charge discharge with a photodiode 90. Under the present circumstances, the photograph carrier (signal charge) accumulated in the charge storage section 92 can maintain constant value, without flowing out anywhere, since it is obstructed by the wall of potential.

[0026] – the exterior from CCD register transfer -- the height of each potential of the photograph gate 91 for photograph gate 93(Sd) for output mode (not shown) charge discharge charge storages (Sc), the charge storage section 92 (phiCH), and the transfer gate 95 (phiTG) -- Low, High, Middle, and Low It sets up. These are controlled by the pulse signals Sd and Sc from the previous pulse generating section 12, phiCH, and phiTG. The signal charge accumulated in the charge storage section 92 is transmitted to the CCD register 960 via the transfer gate 95. The output from a CCD register to the exterior is three steps of transfer pulses phi1 and phi1, and phi 1 so that the existing CCD series may see. It is carried out by the so-called bucket brigade which controlled the height of potential on three level.

[0027] Drawing 5 shows the wave profile of on-the-strength strange modulated light, drawing 6 shows the timing of a sampling of body light 4b shown in drawing 5 (b), and reference beam 4c shown in drawing 5 (c), and drawing 7 shows the timing of the sampling of a synthetic light shown in drawing 5 (d) of body light 4b and reference beam 4c.

[0028] (1) Detect body light 4b which consists of detection fixed light of body light 4b which consists of fixed light. That is, a computer 15 controls the current signal mixer 22 of the modulating-signal generator 2, and makes only the direct current signal from the source 21 of a direct current output to semiconductor laser 3. Semiconductor laser 3 carries out outgoing radiation of the illumination-light 4a which consists of fixed light. Moreover, with the control signal to the 1st and 2nd liquid crystal shutters 11A and 11B, a computer 15 changes 1st liquid crystal shutter 11A into an open condition, and makes a closed state 2nd liquid crystal shutter 11B. Image formation of the body light 4b as for which the part was projected on the object object 6 with the projection lens 5 by penetrating in the half mirror 10 by illumination-light 4a from semiconductor laser 3 and which it reflected with the object object 6 is carried out on a photosensor 9 through a light filter 8 with the image formation lens 7.

[0029] By the pulse generating section 12, a pulse is generated to the timing shown in previous charge storage mode and charge discharge mode, and this is repeated ( drawing 6 ). Photo electric conversion of the body light 4b from the object object 6 is carried out to the signal current by the photodiode 90, and, as for the signal current, predetermined is accumulated in the charge storage section 92 by the count as a signal charge through the photograph gate 91 for charge storages.

[0030] The signal charge accumulated in the charge storage section 92 is as external output mode having shown from previous CCD register transfer. The signal charge accumulated in the charge storage section 92 is transmitted to perpendicular CCD96 first shown in drawing 3 via the transfer gate 95. The transfer to level CCD97 from perpendicular CCD96 is performed by the so-called bucket brigade which controlled the height of potential by three steps of transfer pulses phiV1, phiV2, and phiV3 on three level so that existing CCD saw. The method of the transfer to the external output from level CCD97 is the same as that of the case of perpendicular CCD96. Memory of the output signal is carried out every photodiode 90 which is equivalent to 1 pixel by the distance operation part 14 via the comparator circuit 13 of drawing 1 . The value of the output signal by which memory was carried out for every pixels of these corresponds to the amplitude (Cn-aE) of body light 4b shown in drawing 5 (b), and makes the value A11, A12, and --.

[0031] (2) Detect reference beam 4c which consists of detection fixed light of reference beam 4c which consists of fixed light. That is, a computer 15 controls the current signal mixer 22 of the modulating-signal generator 2, and makes only the direct current signal from the source 21 of a direct current output to semiconductor laser 3. Semiconductor laser 3 carries out outgoing radiation of the illumination-light 4a which consists of fixed light. Moreover, with the control signal to the 1st and 2nd liquid crystal shutters 11A and 11B, a computer 15 makes a closed state 1st liquid crystal shutter 11A, and changes 2nd liquid crystal shutter 11B into an open condition. The part reflects by the half mirror 10, and illumination-light 4a from semiconductor laser 3 is irradiated on a photosensor 9 through a light filter 8. Photo electric conversion of the reference beam 4c is carried out to the signal current by the photodiode 90, and the signal current is sampled the same with having detected body light 4b which consists of fixed light. The count of a sampling (count of are recording) is the same as the time of detection of body light 4b. The value of the output signal by which memory was carried out for every pixel in the distance operation part 14 corresponds to the amplitude (bE) of reference beam 4c shown in drawing 5 (c), and makes the value B11, B12, and --. In addition, as for the start time of day of a

sampling, especially assignment does not have all in the case of detection of body light 4b and reference beam 4c. Moreover, the count of a sampling is made the same as the count of a sampling at the time of detection of the following synthetic light.

[0032] (3) Detect a synthetic light of illumination-light 4a which consists of detection on-the-strength strange modulated light of a synthetic light of illumination-light 4a which consists of on-the-strength strange modulated light, and reference beam 4c, and reference beam 4c. That is, a computer 15 controls the current signal mixer 22 of the modulating-signal generator 2, compounds the modulation current from the modulation current source 20, and a direct current from the source 21 of a direct current, and is made to output them to semiconductor laser 3. Semiconductor laser 3 carries out outgoing radiation of the illumination-light 4a which consists of on-the-strength strange modulated light as shown in drawing 5 (a). Moreover, a computer 15 changes the 1st and liquid crystal shutter 11of ** 2nd A into an open condition with the control signal to the 1st and 2nd liquid crystal shutters 11A and 11B. As for a part, illumination-light 4a from semiconductor laser 3 penetrates a half mirror 10, and the remainder is reflected by the half mirror 10. Illumination-light 4a which penetrated the half mirror 10 is projected on the object object 6, and image formation of the body light 4b as shown in drawing 5 (b) reflected with the object object 6 is carried out on a photosensor 9 through a light filter 8 with the image formation lens 7. Reference beam 4c as shown in drawing 5 (c) reflected by the half mirror 10 on the other hand is projected on a photosensor 9 through a light filter 8. Therefore, on a photosensor 9, a synthetic light as shown in drawing 5 (d) which consists of body light 4b and reference beam 4c carries out incidence.

[0033] Drawing 7 shows the timing of the sampling of a synthetic light which consists of body light 4b and reference beam 4c. The pulse generating section 12 to the timing shown in the photograph gate 91 for charge storages of each photodiode 90, and the photograph gate 93 for charge discharge at drawing 7 Are recording pulse signal Sc1 (alpha 1), The sequential output of Sd1 (beta 1), --, Sc2 (alpha 2) and Sd2 (beta 2), --, Sck (alphak) and Sdk (betak), --, Scn (alphan) and Sdn (betan), and -- is carried out. Here, the multi-statement of the phase alpha of a sampling is carried out by abbreviation regular intervals so that the phase corresponding to the maximum amplitude of on-the-strength strange modulated light may be contained in one period of a synthetic light. the set-up phase -- alpha1, alpha2, --, alphak, --, alphan ** -- the phase of the discharge pulse signals Sd1-Sdn which it carries out and are the opposition -- beta1, beta2, --, betak, --, betan ** -- it carries out.

[0034] First, a charge storage is performed based on are recording pulse signal Sc1

(alpha 1) of a predetermined count. Photo electric conversion of the synthetic light which carried out incidence to each photodiode 90 is carried out to the signal current by the photodiode 90, and, as for the signal current, predetermined is accumulated in the charge storage section 92 by the count as a signal charge based on are recording pulse signal Sc1 (alpha 1) of a predetermined count. Moreover, the pulse generating section 12 discharges the unnecessary charge which outputted the discharge pulse signal Sd1 (beta 1) to the photograph gate 93 for charge discharge of each photodiode 90, and was accumulated in a photodiode 90 and the parasitic capacitance of the circumference of it to a drain 94. Since the photograph gate 91 for charge storages and the photograph gate 93 for charge discharge are driven by opposition, only the charge corresponding to a phase alpha 1 is accumulated in the charge storage section 92 by the count of predetermined.

[0035] The signal charge accumulated in the charge storage section 92 is read by the same approach as the existing CCD series. Memory of the read output signal is carried out every photodiode 90 which is equivalent to 1 pixel in the comparator circuit 13 of drawing 1 . The value of the output signal by which memory was carried out for every pixels of these is made into P1-11, P1-12, and --.

[0036] Based on are recording pulse signal Sc2 (alpha 2) of a predetermined count, it accumulates in the charge storage section 92 by the predetermined count as a signal charge similarly. Only the charge corresponding to a phase alpha 2 is accumulated in the charge storage section 92 by the count of predetermined. The signal charge accumulated in the charge storage section 92 is read as an output signal the same with having mentioned above. Memory of the read output signal is carried out for every pixel in the comparator circuit 13 of drawing 1 . The value of the output signal by which memory was carried out for every pixels of these is made into P2-11, P2-12, and --.

[0037] Like P1-11, P2-11, P1-12, and P2-12, a comparator circuit 13 compares the size for every pixel, and makes the larger one Pp-11, Pp-12, and --. By the are recording pulse signals Sck, --, Scn, this activity is repeated in the same procedure and memory of Pp-11, Pp-12, and -- which were finally obtained is carried out to the distance operation part 14.

[0038] (4) Explain the operation by this distance operation part 14 to a detail below the operation by the distance operation part 14. The optical reinforcement Io of illumination-light 4a when the maximum and the minimum value of omega and a modulation are set to 2E and 0, as shows the angular frequency of the intensity modulation of illumination-light 4a from semiconductor laser 3 to drawing 6 (a) by

which outgoing radiation is carried out from semiconductor laser 3 is expressed like the following formula (1).

Io =E sinomegat+1 ... (1)

[0039] If the distance to the object object 6 sets to 0-2.5m, the modulation frequency needed will be set to 30MHz. The reinforcement of body light 4b as shows the light transmittance of a half mirror 10 to drawing 6 (b) to which the point will carry out incidence of it to the point n by which image formation was carried out on the photosensor 9 if the reflection coefficient in a certain point on a and the object object 6 is set to Cn is expressed like the following formula (2).

An =Cn-aE {sin(omega t+phin)+1} ... (2)

Here, it is phin. It is the phase lag which originates in flight distance from the light source of the light which carries out incidence on a photosensor 9. When distance between semiconductor laser 3 - (object object 6) + (the object object 6 - photosensor 9) is set to L, phin =omegaL/C, however C express the velocity of light.

[0040] On the other hand, the reflection factor of a half mirror 10 is set to b, and from semiconductor laser 3, via a half mirror 10, supposing the optical path length to a photosensor 9 is fully small as compared with the wavelength of a modulated wave, reference beam 4c on the point n of a photosensor 9 is expressed like the following formula (3).

Bn =bE (sinomegat+1) ... (3)

[0041] Synthetic luminous intensity Pn on the point n on a photosensor 9 It is expressed by addition of the formula (2) which asks for the optical reinforcement of body light 4b, and the formula (3) which asks for the optical reinforcement of reference beam 4c like the following formula (4).

Pn =An+Bn =Cn and aE{sin(omega t+phin)+1}+bE (sinomegat+1)

= Cn and aE {sinomegatcosphin+cosomegatsinphin+1}

+ bE (sinomegat+1)

= Cn and a+bE+ (Cn and aEcosphin+bE) sinomegat+Cn -aEsinphin cosomegat =(Cn and a+b) E+root {(Cn and aEcosphin+bE) 2+(Cn and aEsinphin) 2}

- sin (omega t+theta)

= Cn and a+bE+root {(Cn and aE) 2 +(bE) 2+2Cn and abE2cosphin}

- sin (omega t+theta) ... (4)

It corrects. tan theta=Cn -aEsinphin /(Cn and aEcosphin+bE)

A formula (4) is the DC component (Cna+b) E and high frequency component root {(Cn and aE) 2 +(bE) 2+2Cn and abE2 cosphin}.

- sin (omega t+theta)

It becomes ****. Pn It is Pp about peak value. It is Pp if it carries out. Pp =Cn and aE+bE+root {(Cn and aE) 2 +(bE) 2+2Cn and abE2cosphin}

... (5)

It is expressed.

[0042] Therefore, peak value Pp of a synthetic light If the amplitude bE of amplitude Cn and aE of body light 4b, and a reference beam is detectable, phase lag phin with distance information is computable. Since Cn, and aE and bE are the values when emanating without carrying out intensity modulation of the reference beam, intensity modulation is not performed in case it asks for these. In case Pp is calculated, intensity modulation of body light 4b and the reference beam 4c is carried out, a synthetic light is formed, a synthetic wave is sampled by two or more predetermined timing, and the value in the timing from which a sampling result serves as max is detected. One signal in the signal (A11, A12, --) equivalent to the amplitude of body light 4b is set to A. If the signal which is equivalent to the pixel (photodiode) corresponding to Signal A in the signal (B11, B12, --) equivalent to the amplitude of reference beam 4c and the peak signal (Pp-11, Pp-12, --) of a synthetic light is set to B and Pp Formula (5) Pp =A+B+root (A2+B-2+2ABcosphin) ... (6)

The predetermined value by which memory was carried out to Pp, A, and B at the distance operation part 14 since it was expressed is assigned, and it sets to the distance operation part 14, and is phin. It computes and is phin =omegal/C. (however, C velocity of light)

It is alike, and it follows and a depth map is acquired. By performing this about all pixels, the depth map in all pixels is acquirable.

[0043] According to the gestalt of the 1st operation mentioned above, the following effectiveness is acquired.

(b) Since the signal charge which the exact signal charge was obtained and carried out multiple-times are recording about the inphase of on-the-strength strange modulated light since ** was accumulated in the signal charge which discharged the unnecessary charge generated in addition to the sampling period, and was generated at the sampling period at the charge storage section has been obtained, a S/N ratio becomes high and becomes possible [ measuring the distance to a body 6 with high precision ].

(b) Since it is small and cheap and the CCD series in which high-speed operation is possible constitutes the photosensor, without needing expensive means, such as a demodulator on the strength [ optical ] by the crystal conventionally used as a means to restore to light, and an image intensity fire, it becomes it is small and cheap and

possible to measure the distance to a body 6 for a short time.

(c) Since a charge transfer is performed between the one photograph gate 91 for charge storages and charge storage section 92 which adjoined the photodiode 90, and between the one photograph gate 93 for charge discharge, and drain 94 and this sensor 9 can stop the time constant of a register circuit very small, the pulse signal which drives the photograph gate 91 for charge storages and the photograph gate 93 for charge discharge can respond to a 1kHz - 100MHz and RF side. Therefore, since it becomes possible to measure at a high speed and the sampling frequency of a register circuit and the frequency of signal read-out can be controlled independently, the signal charge accumulated in the charge storage section 92 at high speed can be read like the usual video rate at a low speed.

(d) This sensor 9 can be used also as a usual image sensor. Although you may make it operate to the timing shown previously, they are middle, Low, High, and High about the height of the potential of the photograph gate 91 for charge storages, the charge storage section 92, the transfer gate 95, and the photograph gate 93 for charge discharge. If it carries out, a brightness image is acquirable with the same read-out timing as the existing CCD series. Therefore, both a depth map and a brightness image can be obtained by one two-dimensional CCD sensor, and moreover, since the pixel supports 1 to 1, two images can perform a next image processing easily.

[0044] Next, the gestalt of operation of the 2nd of this invention is explained. As for the gestalt of this 2nd operation, unlike the gestalt of the 1st operation, only the distance operation part 14 is constituted by others like the gestalt of the 1st operation. If a formula (5) is transformed, it will become like the following formula (7).

Pp - (Cn and aE+bE)

= root [(Cn and aE) 2 +(bE) 2+2Cn and abE2cosphin}

... (7)

Pp- (Cn and aE+bE) of left part is the amplitude component of a synthetic light, as drawing 5 (d) also shows. Therefore, even if it detects an amplitude component instead of the peak value Pp of a synthetic light, it is phase contrast phin of reference beam 4c and body light 4b. It can be found and distance can be computed. The distance operation part 14 detects the amplitude component of a synthetic light based on this formula (7).

[0045] Next, actuation of the distance operation part 14 of the gestalt of this 2nd operation is explained. First, it asks in the same procedure as the procedure of calculating the peak value of a synthetic light in the gestalt of the 1st operation of the maximum (maximum of a sampling result) of the optical reinforcement of a synthetic

light. In each pixel (photodiode 90), the calculated maximum is stored in the memory in the distance operation part 14. Next, the minimum value (minimum value of a sampling result) of optical reinforcement is calculated with an algorithm contrary to the algorithm which calculated maximum. That is, a synthetic light is sampled by two or more predetermined timing, the value in the timing from which a sampling result serves as min is extracted in a comparator circuit 13, and it stores in another memory in the distance operation part 14. Since the amplitude component of a synthetic light is 1/2 of the value which lengthened the minimum value from the maximum of such optical reinforcement, it computes the amplitude component in each pixel by the distance operation part 14 based on this. The component equivalent to the amplitude of reference beam 4c for which it asked with the amplitude component of a synthetic light for which it asked by the above, and the gestalt of the 1st operation, and body light 4b is substituted for a formula (7), and phase contrast phin is computed by the distance operation part 14. Also according to the gestalt of this 2nd operation, the same effectiveness as the gestalt of the 1st operation is acquired. in addition -- a reference beam -- four -- c -- and -- a body -- light -- four -- b -- the amplitude -- a component -- it is -- bE -- and -- Cn - aE -- each -- DC -- a component -- from -- not asking -- the illumination light -- four -- a -- intensity modulation -- carrying out -- making -- the -- the time -- a reference beam -- four -- c -- and -- a body -- light -- four -- b -- the amplitude -- the above -- having been shown -- composition -- light -- the amplitude -- a component -- having asked -- a procedure -- [(maximum-minimum value) -- /-- two --] -- from -- you may ask .

[0046] in addition, this invention is not limited to the gestalt of the above-mentioned implementation, but deformation implementation is possible for it to versatility. For example, although semiconductor laser was used as the light source with the gestalt of the above-mentioned implementation, since a coherent light is not needed theoretically, it is also possible to use the general light source, for example, a xenon lamp, a stroboscope, etc.

[0047]

[Effect of the Invention] Since only the signal charge which discharged the unnecessary charge generated in addition to the period of a sampling, and was generated at the period of a sampling was accumulated in the are recording section according to this invention as stated above, an exact signal charge is obtained and it becomes possible to measure the distance to an object object with high precision. Moreover, since it is possible for it to be small and cheap and to constitute a signal generation means with the CCD series in which high-speed operation is possible, it

becomes it is small and cheap and possible to measure the distance to an object object for a short time.

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] It is the block diagram of the three-dimensions shape-measurement equipment concerning the gestalt of operation of the 1st of this invention.

[Drawing 2] It is the block diagram of the modulating-signal generator concerning the gestalt of the 1st operation.

[Drawing 3] It is the block diagram of the photosensor concerning the gestalt of the 1st operation.

[Drawing 4] It is drawing having shown the charge transfer typically from charge generating of the photosensor concerning the gestalt of the 1st operation.

[Drawing 5] It is the wave profile of the on-the-strength strange modulated light in the gestalt of the 1st operation.

[Drawing 6] It is drawing showing the timing of a sampling of the photosensor in the gestalt of the 1st operation.

[Drawing 7] It is drawing showing the timing of a sampling of the photosensor in the gestalt of the 1st operation.

[Drawing 8] It is the block diagram of conventional three-dimensions shape-measurement equipment.

[Drawing 9] It is the block diagram of conventional three-dimensions shape-measurement equipment.

[Drawing 10] It is drawing having shown the charge transfer typically from charge generating of CCD.

[Description of Notations]

1 Three-Dimensions Shape-Measurement Equipment
2 Modulating-Signal Generator
4a Illumination light
3 Semiconductor Laser
6 Object Object
5 Projection Lens
4b Body light
8 Light Filter
9 Photosensor

7 Image Formation Lens
4c Reference beam
10 Half Mirror
11A The 1st liquid crystal shutter
11B The 2nd liquid crystal shutter
12 Pulse Generating Circuit
13 Comparator Circuit
14 Distance Operation Part
15 Computer
20 Modulation Current Source
21 Source of Direct Current
22 Current Signal Mixer
90 Photodiode
900 Photodiode
91 Photograph Gate for Charge Storages
910 Photograph Gate
92 Charge Storage Section
93 Photograph Gate for Charge Discharge
94 Drain
95 Transfer Gate
950 Transfer Gate
96 Perpendicular CCD
960 CCD Register
97 Level CCD
98 Photograph Carrier